Shaking up America's Classrooms:
A Vision for Educational Seismology in the United States

A white paper for the U.S. Educational Seismology Network
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Contributing Authors:

Phil Astwood, University of South Carolina
William Boone, Indiana University
Tom Boyd, Colorado School of Mines
Larry Braile, Purdue University
Michelle Hall-Wallace, University of Arizona
Michael Hamburger, Indiana University
Michael Hansen, Ohio Geological Survey
Anita Honkenen, Lincoln-Sudbury Regional H.S., Sudbury, MA
Alan Kafka, Boston College
John Lahr, U.S. Geological Survey
Kent Lindquist, University of Alaska
L. Timothy Long, Georgia Institute of Technology
John Marquis, Southern California Earthquake Center
Rob Mellors, San Diego State University
John Nabelek, University of Oregon
Tom Owens, University South Carolina
Gary Pavlis, Indiana University
Bob Phinney, Princeton University
Larry Ruff, University of Michigan
Jeffrey Sayers, Northview H.S., Brazil, IN
Dan Steinberg, Princeton University

Corresponding Author:

Michael Hamburger
Department of Geological Sciences
Indiana University
Bloomington, IN 47405
(812) 855-2934
hamburg@indiana.edu

Executive Summary

We propose the development of a new consortium of scientists and educators, the ***U.S. Educational Seismology Network*** **(USESN)**, whose mission is to promote the use of seismographs and seismic data for science education. The initiative is built on the premise that educational seismology offers a special opportunity for capturing a student's innate curiosity for natural phenomena in the world around them and that this curiosity can be used as a platform from which a wealth of fundamental principles of physics and earth sciences can be taught. USESN seeks to provide an organizational structure for the coordination of the numerous educational seismology activities that are developing across the country. The primary goals of the organization are to:

(1) promote the installation and effective use of educational seismographs and seismic data;
(2) disseminate high-quality curricular materials and educational services that promote the use of seismology in science education; and
(3) provide an organizational framework for coordination and advocacy of educational seismology across the country.

The initiative is comprised of four principal components:

- ***Provision of technical support*** to participating schools, through (1) coordination of technical support for participating schools, (2) development of a 'seamless data archive' of high-quality seismic data from school seismometers, plus development of effective tools to access these data as well as those from research data repositories; (3) development of 'technical aids' for participating teachers, such as a "Buyer's Guide" for acquisition of new instruments, installation and operation manuals for seismic equipment, and high-quality software installation tools and users' guides for seismological software; and (4) facilitation of data sharing between schools, through development of data exchange criteria and easy-to-use data transfer mechanisms.

- ***Dissemination of educational materials***, through (1) development of a clearinghouse linked to the Digital Library for Earth Science Education (DLESE) for seismological curriculum modules, including compilation and assessment of existing materials, development of new modules with linkages to national and state science standards and teacher guides for each module; (2) enhancement of connections between the research and education communities through professional development workshops, student-teacher symposia; and (3) exploration of new dissemination mechanisms including development of high-quality web-based communication systems.

- ***Coordination with other earth science initiatives.*** USESN will seek to coordinate with Education & Outreach programs connected with other major earth science initiatives, focusing initially on activities connected with (1) the Incorporated Research Institutions for Seismology (IRIS), (2) the Digital Library for Earth Science Education (DLESE), (3) NSF's Earthscope initiative, and (4) the USGS Advanced National Seismograph System (ANSS).

- ***Assessment of existing and planned initiatives*** will be based on an initial phase of evaluation of the needs of the educational institutions in developing educational seismology projects, followed by ongoing project assessment, consisting of telephone, web-based, and detailed interview surveys that will evaluate the effectiveness of the introduction of educational seismology into the classroom environment.

Membership in USESN will follow a four-tiered structure: (1) *full members* will include higher education or research institutions with a mission in seismology research or science education, (2) *affiliate members*, consisting of public and private schools, teaching colleges, and museums or other public education organizations, (3) *institutional affiliates*, consisting of government and private institutions with an interest in seismology or science education; and (4) *international affiliates*, consisting of consortia from other countries with a primary focus in promoting seismology in science education.

Mission and Goals of USESN

Mission

The US Educational Seismology Network is a cooperative entity whose purpose is to promote the use of seismographs and seismic data for science education. It will provide an organizational framework for coordination of educational seismology around the country.

Vision

Our vision is to develop a vibrant national network of academic researchers, college faculty, and school teachers, whose common goal is to enhance science education through the study of seismology. We envision development of a robust network of educational seismographs, recording and networking software, together with pedagogical resources, that allow teachers and students to utilize state-of-the-art seismological data and tools in a wide variety of educational settings. We seek to enhance students' exposure to high-caliber scientific research for students in Physics, Earth Science, and Environmental Science classrooms across the country, and to provide a new resource that can be used for seismological research.

Goals

- Promote installation and effective use of school-based seismographs and seismic data.
- Disseminate, in coordination with other organizations, high-quality classroom materials that promote educational seismology.
- Provide an organizational framework for coordination and advocacy of educational seismology around the country.

Rationale

The initiative is built on the premise that educational seismology offers a special opportunity for capturing a student's innate curiosity about natural phenomena in the world around them—and that this curiosity can be used as a platform from which a wealth of fundamental principles of physics and earth sciences can be taught. Earthquakes, by virtue of their awesome power, their unpredictability, and the broad, sometimes tragic, impact they can have on the daily lives of people, have tremendous potential to capture the attention of students of all ages. If teachers are prepared, they can use this interest to enhance their teaching of mathematics, physical science, earth science, and even social studies. Seismology can be used as a 'hook' and a starting point for teaching fundamental concepts and skills through investigation of real scientific problems with real data. Seismology encompasses a broad array of scientific concepts, ranging from energy flow and elasticity, waves, resonance ... graphing, logarithms, averaging, statistics ... measurement, scientific instrumentation, ... electricity, magnetism, current, voltage, ... use of computers for data collection and communication, ... hazards awareness, preparedness, community response, and government, ... The USESN seeks to provide a mechanism by which our community can harness the power of earthquakes to educate our students.

Background. A series of recent initiatives have extended the arena of seismological research into America's schools have demonstrated real potential for enhancing both

science education and scientific research. Seismic networks have always been used by the research community and by government agencies for the study of the earth's interior, the earthquake process, global and regional tectonics, seismic hazard, and nuclear test monitoring. Until recently, however, both the seismic instruments and access to the seismic data have been off limits to the broader educational community, limited by both cost and technical expertise.

Several recent developments have changed that situation. The development of new, research-quality seismographs at a cost affordable by many schools, combined with high-quality data acquisition and data analysis software and new data communications technologies, have opened opportunities for schools to participate in research activities. These school-based seismographs provide teachers and students with the opportunity to participate in the research community in a variety of formats and at many levels, from conducting basic classroom investigations to station operations, to science projects, to collaborative research with other schools or with research scientists.

The "Network" in USESN. A flourishing national program in seismology-based education requires an infrastructure that provides teachers the support that they need to effectively utilize earthquake data in their classrooms. The model for networked educational seismology goes well beyond the customary networking of stations, data, and data archives, to encompass the networking of teaching resources, of workshop proceedings, and of all other sorts of communication that can energize the teaching of science. The USESN can provide the critical connections, the *Network*, necessary for this program to succeed. A seismograph network is built from individual seismograph stations that are largely independently operated by local station managers. Data from these individual stations are exchanged and shared among station managers and interested seismologists so that the end product is much more valuable to each individual than their original contribution. A seismograph network is effective due to the efforts of the individual operators, a well-defined set of standards for the exchange of data, and the existence of community-supported facilities to assemble and archive the collected data. The USESN can adopt, adapt, and expand this approach to provide other critical connections needed in educational seismology. Indeed, the full spectrum of educational support activities, such as curriculum development, regional or national workshops for teachers and seismologist partners, science fair projects, teacher preparation, and online support services can be given useful form through the networked community of school-based seismic stations. K-12 teachers are renowned for their resourcefulness and their ability to craft existing materials to meet their individual needs. If USESN can provide the infrastructure for those teachers to effectively share their scientific data and educational efforts, then teachers nationwide will naturally form an "educational seismology network" that will greatly enhance their individual efforts.

Applications to Research. The option to site research instruments in schools offers the research community the opportunity to extend seismic monitoring to a large number of recording sites, with access to low-cost power, security, data communications, and technical support. In many areas, such school-based seismic networks may offer significant improvement of, and in some cases the only, continuous monitoring of regional seismic activity. The widespread distribution of school-based seismographs also has the potential to contribute to research goals of improved seismic imaging of the crust and mantle, seismicity and earthquake source mechanism studies, and wave propagation and site effects studies.

Application to Hazard Mitigation. Earthquakes pose a serious hazard in many parts of the United States. The most effective means of reducing the devastating effects of earthquakes is to take precautions prior to their occurrence. When citizens are well informed about earthquake hazards, they will have the necessary motivation and to protect them-

selves and their possessions from the risk. They will also be more likely to support public actions such as improved building codes, or developing earthquake-resistant public infrastructure to reduce societal risk to these hazards. Educational seismology provides a highly effective means for widespread dissemination of information on earthquake preparedness, hazards and risk. Although the educational mission of USESN will focus primarily on seismographs in schools, the school activities developed around the USESN programs will provide an opportunity for linkage with related mitigation-oriented educational activities.

Applications to National Science Education Standards. Two aspects of our educational model are particularly responsive to current reforms in science education, as enunciated in the National Science Education Standards (NSES):

[1] Working with seismic data entails the kind of inquiry-based learning that models authentic scientific activity, as practiced by scientists.

[2] The networking inherent in the model will foster communication among schools and communication between schools and research scientists. Scientists taking the role of personal sponsors of school programs will significantly enhance the status and visibility of science in those schools.

Technical issues. The technology for networking and for station operation has evolved to a point where a school wishing to participate in the USESN can obtain standard instruments and support software, and contribute or retrieve data from regional and national data archiving and distribution centers using tools that are appropriate for classroom use. It is now within reach for a school wishing to participate to obtain and install its own seismic station, and to participate fully in the larger seismological community with only a modest level of technical support.

Coordination of Existing Programs. Educational seismology in the US has grown through several independent initiatives. These include: (1) the Princeton Earth Physics Project (PEPP), which links ten university-based regional networks, currently serving 80 schools nationwide; (2) Michseis/Ohioseis, which has built a network of 18 school and college-based stations in Michigan, Indiana, and Ohio; (3) the South Carolina Earth Physics Project (SCEPP), which is in the process of developing a 50-station educational seismic network in South Carolina; (4) the Los Angeles Physics Teachers Alliance Group (LAPTAG), a network of eight stations in the Los Angeles area, (5) a number of smaller local-area educational seismic networks that are developing across the country; and (6) the Public Seismic Network (PSN) an informal coalition of amateur seismologists, which includes stations at a number of schools. The goal of USESN is not to supersede these organizations, but rather to provide a mechanism for coordination of individual efforts, to provide common technical and educational resources that will enhance all of the educational seismology programs, and provide a mechanism for advocacy for educational seismology.

The Future. To become reality, the USESN will require coordinated exposition and planning and the evolution of mechanisms for fostering a national program, including an understanding of the mix of institutional support, prospective funding sources, and coordination that will be required to make this a successful national program. The goal of this document is to focus and energize the activities among the scientific and educational communities that have led to the development of educational seismology networks, and to foster a new level of expansion, coordination, and support for these educational seismology programs.

Organizational Structure

Membership

We envision a four-tiered membership structure. *Full members* will consist of higher education or research institutions with a mission in seismology education. *Affiliate members* will involve the full range of participating educational institutions: public or private schools, colleges with a primary mission in teaching, museums, and other centers which operate networked educational seismometers. *Institutional Affiliates* will include government and private institutions with an interest in seismology or science education; and *International Affiliates* will be comprised of consortia in other countries with similar programs.

We anticipate that our members will comprise a subset of IRIS member institutions, as well as a small number of additional institutional participants not currently involved in IRIS. Full Members would consist of institutions which sponsor or support educational seismology programs. Until such time as USESN elects to establish formal procedures, membership will be granted by action of the Steering Committee. Guidelines are expected to be flexible. Each member institution shall designate one official institutional representative and one alternate, one of whom will be given voting authority for Steering Committee Elections and other major decisions. Participation in USESN activities will be open to all members of the scientific community. However, there will be only one voting representative from each participating institution.

Deliberation, Discussion, and Action

The membership will meet at least once a year, at a national scientific meeting, and at other times as need arises. Important matters will be taken up between meetings by email or conference call among steering committee members.
For the present, major decisions will rest with majority vote of the Steering Committee, with appropriate consultation with all member institutions.

Steering Committee

A Steering Committee of approximately six members including a Chair and a Secretary will be charged with regular oversight and coordination of USESN activities. The Steering Committee will be selected by majority vote of member representatives at the annual meeting or by email election. They will serve a term of two years and will be eligible for continued service upon re-election. The Steering Committee will be empowered to make decisions on behalf of the organization, upon proper consultation with the full membership on critical issues. If deemed necessary, the steering committee may appoint officers, as required by the growing needs of the USESN community.

The scope of the Steering Committee responsibilities will include identifying priority funding and programmatic needs, and coordinating the preparation of proposals for support, particularly of activities at the national level.

Working groups

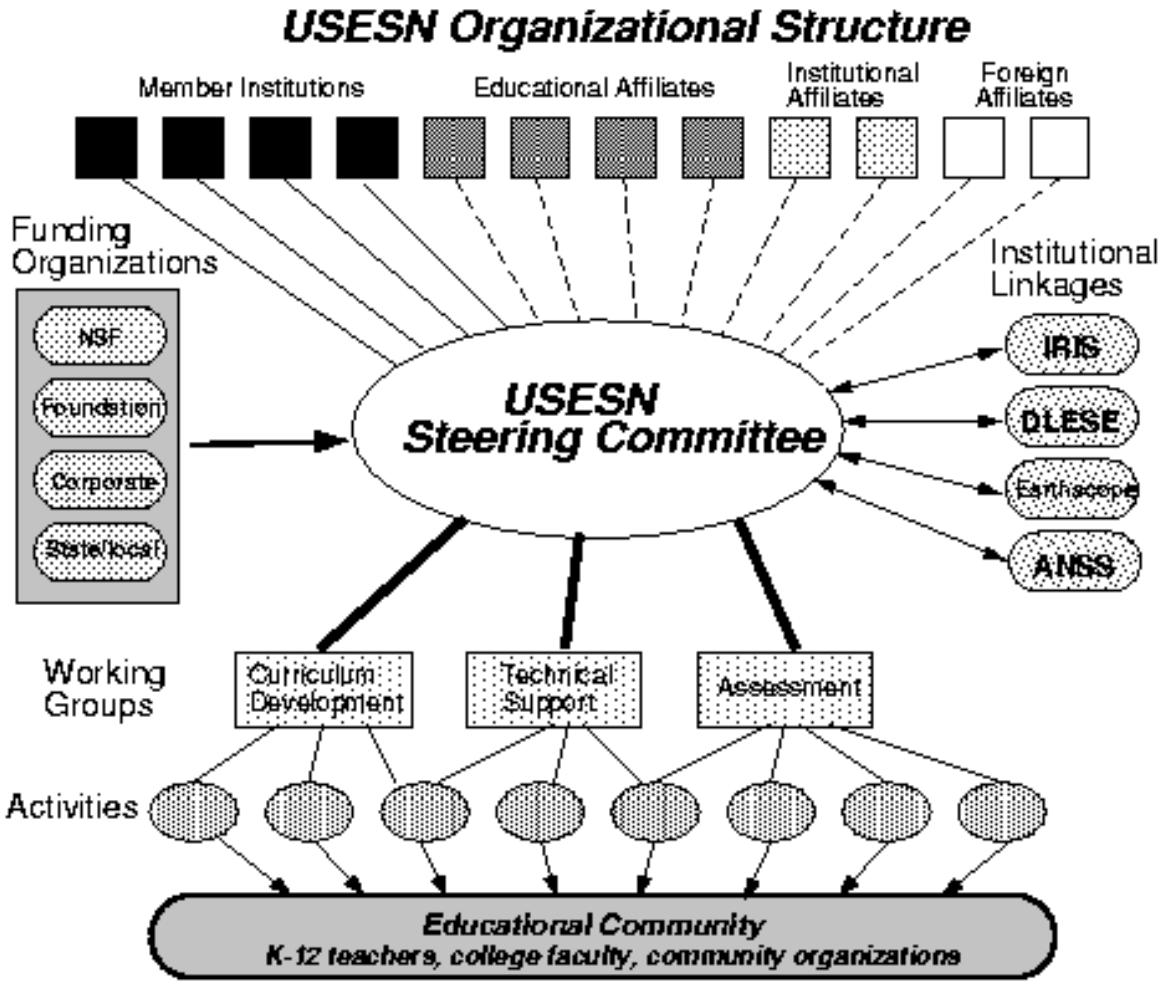
Working groups will be created and appointments will be made by the Steering Committee. Working groups will be tasked with specific efforts, in accordance with the priorities defined by the Steering Committee. We anticipate the formation of continuing working groups for curriculum development, technical support, and assessment, while other groups may be assigned to deal with shorter-term issues, such as the negotiation of grants for infrastructure support from a government or corporate source.

Funding Opportunities

Reflecting the breadth of the community served by USESN, we envision a broad array of funding sources that could support its educational activities. These include federal agencies (NSF Education & Human Resources and Geoscience directorates, USGS, FEMA), state and regional organizations (state departments of education, emergency management agencies), foundations, and corporate entities. Individual groups will continue to develop funding opportunities supporting their own activities. USESN funding initiatives would be focused on support for community-based activities related to technical support, curriculum development, and linkage with other national science initiatives with national-scale impacts. Until USESN has a formal organizational, we may seek a fiduciary agent (e.g., IRIS, AGU) to serve as a pass-through for external funding.

Strategic Plan

In the following section, we summarize the specific activities that we envision as part of the initial phase of USESN efforts. We recognize that both the organization and its strategic plan will evolve with time. The accompanying document lays out the principal components of our efforts in educational seismology, including: (1) Provision of technical support; (2) Dissemination of educational materials; (3) Relations with other geoscience initiatives; and (4) assessment of existing and planned educational programs.



Strategic Plan for USESN

I. Technical Support

Background

The technical support component of USESN will provide infrastructure support to allow teachers to acquire seismic data and to utilize educational seismology materials. An objective is to expand the linkages between K-16 teachers, educational researchers, and professional seismologists. Many technical and training issues can be addressed by the seismologists and passed on to teachers through interactions at all levels. This chain of information will allow the program to grow without limitations inherent in the number of personal contacts that professional seismologists are able to make and maintain. As USESN establishes the network infrastructure, it will be necessary to improve the efficiency of technology transfer so that a large number of teachers can get involved in the program and effectively utilize USESN products even without the direct supervision of a professional seismologist.

Among the range of educational seismology activities that teachers might choose to undertake are:

- Downloading teaching modules, including associated software and data sets, and utilizing them in their classroom;
- Using seismological data from other participating USESN stations and/or from a research seismic network;
- Buying, installing, and operating their own seismograph station; and
- Contributing data from a seismograph station to a USESN data archive.

For the different schools, the level of participation and commitment to the broader national effort would cover a broad range, using our curriculum materials in the classroom to operating a school-based seismograph and contributing to the national data archives. These activities suggest three objectives for USESN technical support:

1. Provision of seamless data access from local, regional, and national data repositories;
2. Development of technical aids to allow any teacher to get involved in educational seismology; and
3. Facilitating data sharing for the educational and seismological research communities.

Objective 1.1 - Seamless Data Access

Most data archives presently are geared toward providing data for research seismologists. While the process is efficient and many of the tools are readily available, they require computer facilities, software tools, and most importantly, a level of expertise that is unreasonable to expect of most teachers and students. USESN must provide the software products that make the internal operations of the data archive invisible to teachers and students. Specific tasks should include:

Task 1.1.1 - Development of a broadly functional data explorer

A full-featured Data Explorer is a critical element of the USESN. A general problem in educational seismology is providing robust and intuitive software tools that allow teachers and students to easily view and manipulate seismic data from a variety of different sources.

Although there are several software tools in different levels of development that provide some of the necessary functionality, there is a need for considerable improvement in these tools. USESN needs to support the development of software to address this need, with feedback from teachers to ensure that the software is consistent with the needs of a wide range of educational applications.

Task 1.1.2 - Development of interfaces to existing data repositories

A related need is the coordination of data access mechanisms at educational and research data repositories to make a wide variety of data available to the educational seismology community. For example, an interface is being developed at the IRIS-DMC to provide much simpler data access for end users and applications. This interface is general enough that it could be implemented at other data centers. Probable data sources include the IRIS Global Seismic Network, the USGS National Seismic Network, data from major educational seismic networks (PEPP, SCEPP, Michseis/Ohioseis, etc), and regional seismic networks. In addition, community efforts to make a wide variety of earth science information available through the Digital Library for Earth Science Education (DLESE) project may provide opportunities to link USESN efforts to a much richer pool of educational materials.

Objective 1.2 - Development of Technical Aids

The commercial software and hardware industries set a high standard for robust, intelligent aids to the installation and operation of products by non-technical end users. For USESN growth to be driven by the interests of the teachers and their students, we must make a significant investment to create technical aids and users guides that are useful to any interested participant. There are several areas where well-written, well-implemented technical aids would be of great value. Specific tasks under this objective correspond to these areas:

Task 1.2.1 – Coordination of technical support

Maintenance support for educational seismographs in schools is a major concern for many teachers. While the technical aids described in this section will help a teacher acquire, install, and operate a seismograph, the long-term issue of how these instruments are maintained and the appropriate role for USESN and its members in this maintenance needs to be defined. Most major educational seismograph projects have some local support for maintenance. However, the long-term level of such support is uncertain. USESN must develop a plan for long-term support of seismographs in schools that optimizes resources from a heterogeneous group of funding sources.

Task 1.2.2 – An Educational Seismograph Buyer's Guide

There are many levels of participation in educational seismology. It is possible to participate without having any seismograph in a school. However, operating an on-site seismograph of some form adds an element of interest and greater involvement in educational seismology that many schools will want. The USESN Buyer's Guide will describe the available instrumentation options, ranging from low-cost desktop demonstration units to high-end broadband instruments. The relative merits of each unit will be outlined and the appropriateness of each instrument for various educational activities will be summarized. Vendor contact information and approximate costs will also be included.

Task 1.2.3 - Instrument testing and certification

USESN, in collaboration with the USGS, national research labs, and the IRIS Passcal instrument center, could provide for testing and evaluation of instrument configurations prior to their inclusion in the Buyer's Guide. An ancillary goal of the seismograph testing and evaluation is the negotiation of educational community pricing for selected seismic equipment.

Task 1.2.4 - Seismograph Installation and Operation Guides

A detailed manual outlining considerations for site selection, installation, and operation of a school-based seismograph station will be developed. The manual will provide success and failure stories and problem-solving tips learned from other participating teachers. This manual is essential if teachers are to install and operate their own instruments. In the seismological community, most of this type of information is anecdotal and exchanged informally. The USESN Seismograph Installation and Operation Guide will provide the means for the teachers to benefit from the knowledge of practicing seismologists regarding seismograph operations. This system can provide front-line support for the majority of operating seismic stations, and minimize the demands on a central instrument support center.

Task 1.2.5 - Robust Software Installation and Users Guide

Currently, most software for educational seismology is difficult for a teacher to install without assistance. This may prevent many teachers from actively participating in the program. The USESN must address this issue and provide auto-installing software applications and data collection modules for school-based seismographs. When installation tools and detailed users guides are developed for USESN, teachers could obtain, install, and begin using educational seismology software on their own.

Task 1.2.6 – Reconciling data communications and security issues

Many of the most innovative uses of the internet for educational seismology involve data transmission between a school and outside servers that manage data, provide classroom resources, and provide real-time exchange of data. The presence of security firewalls in schools often produces a serious roadblock for any data communications beyond filtered web browsing. Much of the security development has taken place by external contractors and with little standardization, and many schools have difficulty configuring firewalls to suit the specific needs of the seismological program. Consequently, USESN must provide technical information and support to school Internet Coordinators in addition to teachers. USESN will work with both software providers and technical support groups to identify practical solutions to this problem and will publish appropriate technical aids.

Objective 1.3. Facilitate Data Sharing

Exchange of data between school seismograph stations and other school or university researchers is a critical element of USESN. This sense of contributing to a larger project is often cited as a motivational element of educational seismology. USESN must take a leadership role in defining how this exchange takes place, in facilitating data transfer, and in ensuring proper documentation of the variable quality of the school seismic data.

Task 1.3.1 - Definition of Data Quality

Data is at the heart of educational seismology and guaranteeing the quality and accessibility of the data is essential. In additional data from many USESN stations will be useful to other educational institutions, to regional seismic networks, and for general research purposes.

In order to maximize the value of such seismic data, however, we must strive to maintain a high standard of data quality in terms of instrument response, precision of timing, orientation of sensors, etc. At the same time, we must recognize that not all USESN operators will have the capability or skill to maintain the level of quality required of a research seismic station. We propose to address this issue by developing a set of Quality Indicators and a plan for reviewing stations and data. For example, research-grade stations such as the GSN would be Quality A stations in terms of their response and timing. Some USESN stations may have accurate GPS time, but are not routinely calibrated for sensor response. These would be Quality A in terms of timing and Quality B in terms of response. The main task is for the appropriate group of individuals to consider the available instruments and define meaningful quality codes.

Task 1.3.2 – Facilitation of Data Exchange

Among the current educational seismology programs, the mechanisms for contributing data to and maintaining a data archive are highly heterogeneous, often cumbersome and frequently reliant on manual methods of data transmission and archiving. The USESN must seek to identify a number of reliable, user-friendly methods of data exchange that minimize the effort required of the station operators, while maximizing the reliability of the data transfer process. We anticipate that a number of data repositories might exist around the country. The USESN will provide a means for a teacher to contribute to an appropriate data repository and for sharing data between repositories. We anticipate working closely with the IRIS Data Management Center on possible collaboration on data archiving through DMC.

II. Educational Materials

Background

The primary goal of educational seismology networks is improved science education. To reach this goal USESN seeks to make the use of seismographs in schools as easy as possible for teachers. This will go a long way in facilitating teachers' efforts to develop inquiry-based learning in their classrooms. A web-based central clearinghouse with software tools and curriculum materials that encompass a broad range of subjects related to educational seismology will be made available to all science teachers. USESN must ensure that these are high-quality, standards-based educational materials. The USESN must focus its efforts on development of materials specifically related to seismic instrumentation and seismic data analysis as components of physics and earth science curricula. However, modules that link these to earth system science as a whole and lessons that provide background necessary for USESN projects will also be included in curriculum dissemination efforts. Education modules will cover subjects that address the National Science Education Standards in earth science, physics, environmental science, and mathematics. They also provide unique opportunities for linkages between the sciences and other disciplines, including geography, history, foreign languages, and even the arts.

Objective 2.1. Development of Clearinghouse of Educational Resources

There currently exists a wide array of educational materials related to seismology developed by members of the earth science and education communities. These materials include E&O websites, lesson plan modules, computer software, and printed materials. There is a wide variation in quality of these materials. Many are excellent and can immediately be used as tools in the classroom and others are not useful for the classroom in their present form.

USESN will work with the authors to provide a central clearinghouse for evaluation and distribution of these materials and this clearinghouse will be linked with DLESE.

Task 2.1.1 – Produce and maintain a comprehensive list of educational materials

USESN will be at its best when students are doing real science projects in near-real time, with real data recorded on their own seismographs. Thus, USESN will compile a complete set of useful and effective curriculum modules that emphasize the use of data obtained from educational seismographs. Additionally, we will include modules that use educational seismology topics to teach broader science concepts including the scientific process, and the Earth as a system.

The most pressing need is for educational materials that use data obtained from the network of school seismographs. Some lessons on *Earthquake Location* and *Plate Tectonics* are already available, but many others, such as lessons on *Earthquake Magnitude* and *Identification of Seismic Waves*, still are needed. A high priority will be attached to curriculum modules that take full advantage of data recorded by networked seismographs. Lessons that take advantage of recordings of a recent newsworthy earthquake are often the most motivating for students. Lesson plans that use archived data are also needed, because not every school that participates in the USESN program will have an active recording seismograph and not every earthquake data set will illustrate critical principles needed for a specific investigation.

We will start the compilation process by reviewing and evaluating existing materials developed by educational seismology programs, institutional E&O sites (e.g., IRIS, USGS, SCEC, CERI, FEMA), and other educational organizations (e.g., Virtual Earthquake, RiverDeep.com, etc.). From these sources and other materials, a digital library of high-quality materials will be made available for dissemination to schools. In addition, one of the long-term goals of USESN will be to produce new education materials. Ultimately, USESN may seek to develop a common format for distribution of these materials. Adaptation of existing materials into a few standard formats will make it easier for teachers to use.

Two factors are critical in effectively disseminating curriculum materials. First curriculum materials must be related to relevant educational standards in science, mathematics, technology and geography. This step is critical, as education standards are being developed and implemented in most states. Second, the curriculum materials will need teaching guides that contain critical information about the content and pedagogy of the materials and how they can be used to supplement to a curriculum. Teaching guides will also supply critical metadata for search engines and central clearinghouses such as the Digital Library for Earth Science Education (DLESE). An ultimate goal of these efforts is an extensive, easily searchable database on subject matter, grade level, teaching method, and education standards. USESN will collaborate in developing teching guides from which metadata can be harvested for inclusion in the DLESE database.

Task 2.1.2 - Linkage with science standards

Educational materials should be reviewed for alignment with national science education standards and when possible state standards. All materials disseminated by USESN should meet some specific set of national science education standards. While individual state standards will usually carry more weight with teachers, it is beyond the scope of USESN to specifically tailor modules to standards in all 50 states. However, states often base their standards on the national standards and teachers will be able to use the national standards as a guide. USESN will encourage members in states with thriving educational seismology

programs to produce and disseminate guidelines for relating curricular materials to their state's standards.

Task 2.1.3 – Teaching Guides

Lesson modules should contain, or have associated with them, a teaching guide that contains information about the lesson to help teachers decide whether or not the lesson fits into their curriculum. The information within the teacher pages should include at least the following: grade level targeted; national standards addressed, (and, when available, the state standards); science content; teaching methods, materials needed; time needed to complete lesson; glossary of terms; suggested student assessment methods; computer requirements (if applicable); data requirements; and ancillary information (links to websites, suggested readings, related lessons).

Task 2.1.4 - Curriculum module development

USESN will provide a framework for development of new educational modules. Member institutions will be encouraged to seek funding to develop exemplary curriculum modules that fill an educational need not previously addressed. These new modules should be peer-reviewed for science content and pedagogy, and incorporated into the USESN educational materials clearinghouse.

Task 2.1.5 - Dissemination of Materials

A web-based, central clearinghouse for the materials listed above will be supported by USESN. An easily navigable and searchable website that contains the software, data access and curriculum modules will be maintained by USESN. This website will utilize information in the teaching guides as metadata to facilitate searching and cataloging the materials. Distribution can be expedited by taking advantage of the DLESE initiative, which is being set up to collect and disseminate earth science education materials, including data, curriculum modules and software. DLESE has included in its mission a system for reviewing and evaluating materials. This is a potentially valuable resource of which USESN should take full advantage.

The USESN central website must be user-friendly; however, workshops for classroom teachers to learn about educational seismology and how to use the materials available on our web site should be conducted. The ideal places for these workshops are at regional and national NSTA meetings, AGU and GSA meetings, and at host site universities.

Objective 2.2. Connections between Participating Universities and Schools

Teachers participating in the USESN community will gain experience in the use of advanced technology and networking communications by using computers, databases, websites, curriculum clearinghouses, and state-of-the-art educational seismographs. Through this process, they will develop a deeper understanding of Earth, wave theory, and seismology that can be used in their classroom. Through a collaboration of research scientists and teachers USESN will be instrumental in enabling student-directed learning through project-based scientific inquiry and hands-on studies using real data recorded at schools.

Task 2.2.1 - Teacher professional development and support

USESN will provide support for faculty members to conduct teacher workshops locally and at regional and national conferences. A central clearinghouse of materials from previous workshops should be made available to assist development of future workshops. Member institutions will seek out funding to sponsor workshops, and may coordinate funding programs with other member institutions. These workshops should introduce the basics of seismograph operation, networking technologies, and curriculum modules. Follow-up workshops should be provided for teachers who participate in USESN long-term in order to refresh and strengthen their skills.

Task 2.2.2 - Facilitating teacher-student-scientist interactions

Student-directed learning in the classroom and beyond is a major goal of educational seismology. Beyond the scope of classroom learning, some students will take advantage of their seismographs by conducting science projects. Scientists will participate as mentors to students. Hosting of student-teacher symposia by participating institutions can further enhance this type of student involvement.

Task 2.2.3 - Web site for participating schools

USESN can assist student and teacher collaboration among schools by providing multiple interfaces for communication on the internet such as school home pages, bulletin boards and conferencing software. Many K-12 schools can not provide teachers with these services yet they can be vital to real collaboration and learning. For example, large and newsworthy earthquake events generate tremendous excitement among students and teachers in the educational seismology programs. Nationwide investigations of these events can be coordinated via the web to encourage participation and stimulate interest. We will encourage participating teachers to post results of student investigations on university websites and share data with other schools.

Task 2.2.4 – Fostering community interaction

USESN can enhance communication between research institutions and the communities in which they reside. The educational opportunities described here can be extended to contacts with museums, continuing education programs, amateur scientific groups, state and local emergency agencies, and other public organizations. USESN can build on the major, high-visibility scientific programs such as Earthscope and the Advanced National Seismic System to further extend public interest in, and support for, scientific research.

III. Relations of USESN to other programs

Background

The USESN must evolve as a component of a much larger, national and international, seismology infrastructure. A critical issue for the success of USESN is coordination with the government and private agencies that form the fabric of the seismological community. In the near term, there are three programs upon which the USESN community will need to focus while coordinating its activities: (1) the Incorporated Research Institutions for Seismology (IRIS); (2) Earthscope, a proposed major research initiative through the National Science Foundation (NSF); and (3) the Advanced National Seismic System (ANSS), now in a startup phase through the U.S. Geological Survey. In addition, DLESE is a key player in our plans for dissemination of curriculum materials and other educational

information. We address each of these elements in separate sections below.

Incorporated Research Institutions for Seismology (IRIS)

IRIS represents the academic, research community of seismology in the United States (with 91 current members) and the principal participants in USESN largely represent a subset of the greater IRIS community. The primary distinguishing feature of USESN membership from IRIS membership is the focus on educational issues, and the involvement of K-12 teachers and 4-year college faculty. The primary focus of IRIS is support for the research infrastructure of seismology; however its E&O element seeks to disseminate seismological research results, data and educational materials to a wider audience. USESN, in contrast, reverses the priorities. The primary focus is education, with a secondary goal of extending seismological data-gathering capabilities through participation of educational institutions. Thus, IRIS and USESN will inevitably overlap in both membership and interests.

Earthscope

Earthscope is a project of unprecedented scale for the solid earth sciences that has been proposed for the NSF's Major Research Equipment (MRE) program. Earthscope is comprised of four different elements: the San Andreas Fault Observatory at Depth (SAFOD), the USArray, the Plate Boundary Observatory (PBO), and the Interferometric Synthetic Aperture Radar (InSAR) initiatives. Of these, two of the programs, USArray and PBO, carry the greatest potential to the USESN community, and are unique in the realm of large science projects because of their larger geographic extent. USArray is a nationwide experiment while the PBO is focused primarily on western North America. The geographic distribution of the projects holds the potential for unprecedented involvement of schools. USESN has a clear interest in collaborating with both of these programs in two ways. First, the technical and curriculum goals of USESN coincide with those of Earthscope, particularly the USArray component. All advances USESN can make in these areas will directly benefit Earthscope E&O activities, and vice versa. Second, USESN can serve a role as a long-term legacy of USArray and PBO, because as USArray is deployed it is expected that local schools will be invited to participate in the experiment when possible. Thus, as USArray moves across the country it will leave behind a strong interest in educational seismology in area schools. Some of these schools may wish to extend their participation in a national seismology program by operating a seismic station after the departure of USArray or PBO facilities from the region. Since these programs may approach operational status in 2-4 years, it is timely for definition of the possible role of USESN in these major initiatives.

Advanced National Seismic System (ANSS)

The ANSS is a new initiative spearheaded by the U.S. Geological Survey to organize, modernize, and standardize operation of seismic networks in the U.S. and dramatically improve the Nation's ability to respond effectively to damaging earthquakes, volcanoes, and tsunamis. When fully implemented the National Seismograph Network will be expanded from 56 to 100 broadband stations, 1,000 seismographs will be added or replaced with modern instrumentation in the most critical regional networks, and 6,000 new strong-motion instruments will be installed in the urban areas at greatest risk from damaging earthquakes. A modern, robust telecommunications system will be established to bring the recorded data to monitoring centers, where it will be made available to seismologists throughout the U.S.

Although the ANSS is primarily an instrumentation project with no specific E&O component, it is part of the National Earthquake Hazards Reduction Program (NEHRP), which does have long-term E&O goals. The USESN community will focus on making tools available to the education community so that data from the ANSS can be easily accessed and used for

educational purposes. This data will naturally augment the data collected by school-based USESN seismic stations.

Digital Library for Earth Science Education (DLESE)

DLESE is conceived as an information system dedicated to the collection, enhancement, and distribution of materials that facilitate learning about the Earth system at all educational levels. The form and function of DLESE are defined by its unique focus on Earth system education. DLESE supports Earth system education by:

- developing collections of high-quality materials for instruction at all levels and covering all components of the Earth system,
- providing access to Earth data sets and imagery, and developing the tools and interfaces needed to enable their effective use in education,
- developing discovery and distribution systems to efficiently find and use materials encompassed by the DLESE network,
- providing support services to help users find, use, and create learning materials, and
- developing communications networks to facilitate interactions and collaborations across all interests of Earth system education.

DLESE is envisioned as being a distributed resource, built by the community. Collections, services, and tools are to be developed and maintained by numerous partners rather than being housed at a single centralized facility. Construction of the library as a federated effort is now underway. To coordinate the DLESE effort and integrate library collections, services, and policies, a governance structure and central program office, the DLESE Program Center (DPC), have been established. The DPC, located at the University Corporation for Atmospheric Research, is engaged in both the community and technical aspects of library construction and management.

Earth system educators have developed a strong consensus that DLESE will be most effective if it is an integral part of a larger network of digital libraries. In particular, DLESE shares many goals with the National SMETE Digital Library (NSDL) effort. As such DLESE is actively participating in a national dialogue that will lead to the development of a federated NSDL.

Objective 3.1. Develop a Working Plan for Data Collection and Dissemination.

To maximize the utility of data collected by a USESN station, data must be collected and organized in a manner for efficient dissemination to the larger community. The obvious organization with both the expertise and the resources for data collection and dissemination is the IRIS Data Management Center (DMC).

Task 3.1.1 - Set data collection standards.

IRIS has already agreed in principle to accept data from the USESN networks, provided they are assured some quality control through a network operator. As discussed in the Technical Support section, we will develop and implement appropriate standards of quality control so that USESN data can be incorporated into the IRIS Data Management Center. The preferred model for assuring quality control is that used by the Data Collection Center (DCC) for the Global Seismic Network.

Task 3.1.2 - Define data dissemination mechanisms appropriate for educational seismology

IRIS has existing tools for data dissemination via the web and is working on more advanced tools under the FISSURES program. Because IRIS's primary customers are the research

community, however, these tools are not designed to be readily usable by the educational community. IRIS has, however, partnered with DLESE and currently has funding under a join DLESE/IRIS NSF proposal to begin addressing issues associated with data dissemination for educational purposes. USESN will also advocate for, and work with IRIS, to develop a mechanism to provide appropriate data dissemination tools through the IRIS DMC.

Objective 3.2. Develop a Working Model for the Relationship with IRIS.

Our organizational plan assumes that USESN will evolve with a close association with IRIS. We need to ensure that these relations are complementary, rather than competitive or duplicative. Important details of how the two groups will interact, however, still need to be developed.

Task 3.2.1 - Work with IRIS Execom to define the USESN-IRIS relationship.

The USESN plan will be presented for discussion to the IRIS Executive committee at a meeting planned for early 2001. We will propose that a task force be appointed to refine the organizational relationship in time for approval by both organizations at the annual IRIS workshop in June of 2001.

Objective 3.3. Define the Role of USESN in USArray and PBO.

Because of the large overlap between the goals of USESN and Earthscope's E&O activities, the need to define this relationship is obvious. Furthermore, since IRIS will probably be the primary coordinator for USArray this adds a further overlap in interests. We need to work with IRIS and the USArray steering committee to define this relationship. Near term tasks include:

Task 3.3.1 - Meet with the USArray steering committees.

Representatives of the USESN need to meet with the USArray steering committee and IRIS E&O to identify areas of mutual interest and to define specific goals for an E&O component of USArray.

Task 3.3.2 – Construct a proposal to develop educational modules for USArray.

A good case can be made to immediately start the process of developing educational modules needed for USArray—even in advance of full funding for the initiative. The USESN community represents the core group that would be available to provide this for USArray. We should define a funding target, form a working group of prospective participants, and draft a proposal for this purpose.

Task 3.3.3 - Work to define the role of USESN in PBO.

The Plate Boundary Observatory will involve a more diverse mix of geophysical instrument-ation than USArray. Nonetheless, the educational elements of the program have a great deal of overlap with USArray, and will require education-friendly interfaces that allow K-16 students to obtain and work with data from the facilities. Representatives of the USESN should be in contact with the PBO steering committee to identify areas of mutual interest.

Objective 3.4. Expand linkages with the Digital Library for Earth Science Education.

Because of their commitment to provision of high-quality earth science data into America's science classrooms, there is an obvious linkage between USESN and DLESE. We anticipate working closely with DLESE both on mechanisms of data sharing between schools and on collection, evaluation, and dissemination of educational materials through DLESE's archive.

Task 3.4.1 - Collaborate with DLESE Dataset Working Group

The USESN will participate in an educational, community-wide effort sponsored by DLESE. These efforts are aimed at (1) facilitating the discovery of data across distributed archives and data types, (2) the development of tools to help instructors and learners parse, process, and visualize datasets, (3) the integration of seemingly disparate datasets in a variety of learning environments, and (4) the development and dissemination of educational content that utilizes datasets and datastreams.

Objective 3.5. Expand the Utility of the emerging ANSS Resources to Serve the Educational Community.

Task 3.5.1 – Ensure that ANSS data are accessible to the educational community.

The ANSS will provide a wealth of data that will be the backbone of most educational uses of seismic data, such as a national event catalog that will be invaluable to inquiry-based learning exercises on seismic events. ANSS data need to be available seamlessly to the educational community, both as a stream of real-time data and as sets of seismograms for specific events. We need to work within the existing committee structure of ANSS to provide the coordination required to make this happen. We note that the activities of educational seismology are particularly suited for "informal education", which includes many forms of outreach to the general public. Consequently, the development of an educational interface for ANSS data may serve a broad array of public information functions, which is an important mission for the USGS.

Task 3.5.2 – Advocate for educational efforts within ANSS.

Regional Advisory Committees will provide input on the siting of ANSS seismic instruments throughout the country. The USESN should be in contact with the Regional Coordinators to discuss how to coordinate these efforts. The USESN could contribute by facilitating the location of seismic or other equipment in schools. In many cases, public schools provide a natural home for permanent seismic stations. They are on public land, can provide power, security, and continuous internet communications, and they have natural status as a public institution that could be beneficial to a federal agency. In many cases, school sites would be less than ideal because they are usually located within more densely populated areas, thus resulting in higher levels of cultural noise. In other cases, however, there may be school sites that provide acceptable compromises between site logistics and seismic noise. The USESN could help provide a mechanism to put state-of-the-art instrumentation in a select set of schools. Even in areas where schools are a poor choice for an actual seismic sensor, they may still be a good choice for providing an inexpensive connection to the internet. Mechanisms already exist to transmit digital data from a remote site to a receiver at a school. This configuration could provide an opportunity for getting schools involved in the seismic data acquisition process. Both of the above could also build on efforts by USArray or PBO to deploy geophysical instruments at or near a school.

Task 3.5.3. Development of an E&O component of ANSS.

In contrast to the other geophysical programs described in this section, the ANSS currently has no formal E&O component. USESN can serve both to advocate for an active E&O mission of ANSS, and can work with USGS to fill this void.

IV. Assessment

Introduction

Assessment is a critical element of any educational initiative. Operating in several stages, the assessment of this program will measure the extent to which the USESN goals are appropriate, that they are being met, and that the program has succeeded overall. In this section, we summarize the principal goals of the assessment component of USESN. We will build on the assessment efforts of PEPP and SCEPP, the largest of the existing programs, which are beginning to yield insights into the successes and limitations of the current educational seismology initiatives. Specific assessment tasks of the curricular component of USESN are presented in the Appendix A.

Objective 4.1. Needs Assessment

The majority of the participants in this program have been associated with education throughout their careers. However, most of us have dealt primarily with college and university teaching and have limited experience in schools. Based on our experience, we believe that access to educational seismographs and real seismic data can spark the interest of students and form a foundation for effective teaching and learning. However, the first step in preparation of the program should involve the collection of data to investigate these beliefs. Surveys need to be prepared and sent to schools that currently own seismographs to find out if they are used and how useful the faculty have found them to be. Is there indeed a demand for these materials? Similarly, existing classroom activities based on seismic data and software that has been developed to use such data need to be sampled and examined.

Objective 4.2. On-Going Project Assessment:

Once projects have been designed to address each of the goals, and the projects have been initiated, their progress needs to be assessed.

Two questions can be asked concerning the USESN goal of promoting educational use of seismographs and seismic data:

1. What means have been used to promote the installation and effective use of educational seismographs? How effective have the means been?
2. How will we define “effective use” of seismographs and seismic data? Are they being used in this way?

Working with classroom teachers and seismologists, an evaluator needs to design written and telephone surveys, combined with detailed on-site interviews, that can be employed to answer these questions.

The USESN's second goal, dissemination of effective educational materials, is described in Section III of this paper. In each case the assessment can ask how many of the "tasks" under each objective have been accomplished, and to what extent has each objective been met. We outline an approach to each of these tasks in Appendix A.

Objective 4.3. Summative Assessment

The extent to which this project reaches our third goal, to provide an organizational framework for coordination and advocacy of educational seismology, will be based on its success at collecting, installing, and creating the necessary educational tools. Our success will be measured by the growth of the educational seismology movement, quantified in part by the numbers of participating institutions, number and geographic distribution of schools, number of operating seismic stations, quantity of data contributed or accessed from data archives, and number and quality of classroom activities, student research projects, and curricular materials developed under the auspices of the USESN. Similarly, a reflection of the success of USESN might be the number and quality of seismology workshops, sessions at national meetings, and scholarly publications that emerge from USESN-supported programs.

If properly carried out, these projects will establish USESN among seismologists and educators as a source of timely, appropriate, and useful educational ideas and materials. In this position, USESN will be able to speak for seismology education in a way that no other organization can. An assessment of its effect would simply be a measure of the extent to which teachers and scientists recognize USESN as a source of educational materials and a voice for educational seismology.

APPENDIX A: Assessment of Curricular Materials

Task 2.1.1 – Produce a comprehensive list of educational materials

Assessment - Many activities that have been produced as a part of educational seismology projects (PEPP, SCEPP, or PSN) and activities developed for more general education projects directed by the USGS or FEMA have already been subjected to some evaluation. However, all activities that will be compiled by this program need to be subjected to an evaluation by seismologists and teachers. The evaluation must ask: 1) Is the activity's scientific content significant and correct, 2) Is the activity set at an appropriate academic level, and 3) Does it employ sound pedagogy?

Task 2.1.2 - Linkage with science standards

Assessment - A panel of educators needs to determine which science standards this project should attempt to address. The National Science Education Standards are most likely to apply, but the panel should also consider National Geography Standards, National Mathematics Standards, and the less formal National Environmental Education Standards and National Technology Education Standards..

Task 2.1.3 – Teaching Guides

Assessment - Section III contains a list of the important components for these materials. Most of the components are simple information about the activity and how to teach it, however, it is also very important that each module contains, or provides ready access to, a synopsis of the scientific information on which the activity is based. It is a common error to assume that teachers are sufficiently acquainted with all of the scientific content they are expected to teach. A panel of experienced teachers should be the final arbiters of the materials to be included in the teaching guides and these same teachers should examine and approve the scientific information provided.

Task 2.1.4 - Curriculum module development

Assessment – This process needs to be assessed at three points: 1) Teachers need to be surveyed to determine the areas in which new material is needed, and this information should be combined with input from seismologists to determine the number and type of modules to be developed, 2) Classroom teachers need to review the overall format for the new modules, and 3) A similar panel must work with seismologists to review and revise the modules as they are being prepared.

Task 2.1.5 - Dissemination of materials

Assessment - The two most important questions to ask about a dissemination system are: 1) Do potential users (teachers) believe they can learn and use the system? , and 2) Do they use it? As with many of the other aspects of this program, teachers need to be involved in the design and implementation from the beginning.

Task 2.2.1 - Teacher professional development and support

Assessment – Two areas need to be examined here. 1) Teachers, or other presenters, need to be prepared to present effective workshops. These workshops should be designed and evaluated by teachers who have experience working with peers. 2) The success of the resulting workshops should be evaluated using pre and post surveys in which the participants document the extent to which they understand the material presented and report on the extent which they believe they will be able to use it in their classrooms.

Task 2.2.2 - Facilitating teacher-student-scientist interactions

Assessment – As suggested in Section III, the most effective way to encourage independent research by students is to encourage such activity among teachers. This is really a two-step process. Teachers should be given the opportunity to work with scientists on individual research projects, and the scientists should then work with the teachers to encourage students to initiate projects of their own. The most informative assessment of such projects is an

evaluation of the participants' (teachers or students) beliefs about the value of research and their own ability to do it.

Task 2.2.3 - Web site for participating schools

Assessment - The success of a web site is easily measured by the extent to which it is used. If, however, some web sites are not used significantly, one should determine the reason. In most cases, students are the intended users and thus they should have a significant part in determining the design and content of a web site.

Task 2.2.4 – Fostering community interaction

Assessment - Schools are the proper location for long-term projects and research opportunities, but museums and other public education programs contact a far greater number of potential learners. USESN should determine other locations where educational seismographs might be available and where there is an interest in the use of seismic data.

APPENDIX B: List of Acronyms

AGU	American Geophysical Union
ANSS	Advanced National Seismic System
CERI	Center for Earthquake Research and Information
DLESE	Digital Library for Earth Science Education
DMC	Data Management Center (IRIS)
FEMA	Federal Emergency Management Agency
GSA	Geological Society of America
GSN	Global Seismic Network (IRIS)
InSAR	Interferometric Synthetic Aperture Radar
IRIS	Incorporated Research Institutions for Seismology
LAPTAG	Los Angeles Physics Teachers Alliance Group
MRE	Major Research Equipment (NSF)
NSES	National Science Education Standards
NSF	National Science Foundation
NSTA	National Science Teachers Association
PBO	Plate Boundary Observatory
PEPP	Princeton Earth Physics Project
PSN	Public Seismic Network
SAFOD	San Andreas Fault Observatory at Depth
SCEC	Southern California Earthquake Center
SCEPP	South Carolina Earth Physics Project
SMETE	Science Mathematics Engineering and Technology Education
USESN	U.S. Educational Seismology Network
USGS	U.S. Geological Survey